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Relation Between Spot and Futures
An Analysis of Nikkei Index and Nikkei Futures During the October 1987 Crash

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Summary

October 1987 crash has raised important questions about the relationship between spot and futures markets in general and spot and futures markets of securities across countries. This international aspect of the crash has been highlighted by Roll (1989). In the spirit of Roll, we tested for the linkages between Nikkei December 1987 Futures (NKDEC), Nikkei March 1988 Futures (NKMAR) contracts traded in Singapore International Monetary Exchange (SIMEX), the Nikkei Index (NKSP) and the Dow Jones Industrial Average (DJIA) before and after the crash.

Granger Causality tests were performed to test the following hypotheses: (1) changes in NKSP is caused by NKDEC; (2) changes in NKSP is caused by NKMAR; (3) changes in DJIA is caused by NKDEC; and (4) changes inDJIA is caused by NKMAR. All four hypotheses were rejected and unidirectional causality were established from (1) NKSP to NKDEC; (2) NKSP to NKMAR; (3) DJIA to NKDEC; and (4) DJIA to NKMAR. Further regression analysis showed that the dependence of NKDEC and NKMAR on NKSP and DJIA to be very high.

Résumé

Relation entre comptant et à terme : une analyse de l'indice Nikkei et des opérations à terme Nikkei pendant le krach d'octobre 1987

Le krach d'octobre 1987 a soulevé des questions importantes sur la relation entre les marchés au comptant et à terme en général et les marchés au comptant et à terme de valeurs dans plusieurs pays. Cet aspect international du krach a été souligné par Roll (1989). Dans l'esprit de Roll, nous avons testé les relations entre les contrats à terme de décembre 1987 de Nikkei (NKDEC), les contrats à terme de mars 1988 de Nikkei (NKMAR) échangés dans le Système Monétaire International de Singapour (SIMEX), l'Indice Nikkei (NKSP) et l'Indice des valeurs industrielles à la Bourse de New York (DJIA) avant et après le krach.

Les tests de causalité de Granger furent effectués pour tester les hypothèses suivantes: (1) les changements dans NKSP sont causés par NKDEC; (2) les changements dans NKSP sont causés par NKMAR; (3) les changements dans DJIA sont causés par NKDEC; et (4) les changements dans DJIA sont causés par NKMAR. Les quatre hypothèses furent rejetées et une causalité unidirectionnelle fut établie de (1) NKSP à NKDEC; (2) NKSP à NKMAR; (3) DJIA à NKDEC; et DJIA à NKMAR. Une analyse des corrélations plus approfondie démontra une dépendance très élevée entre NKDEC et NKMAR sur NKSP et DJIA.

Relation between spot and futures: an analysis of Nikkei index and Nikkei Futures during the October 1987 Crash.

1. Introduction

The events in October 1987 has shown how interdependent the world bourses are. Shocks in one stock market quickly spreads and affects events in others. The 1987 crash also vividly illustrated how securities and derivatives of the securities are interlinked. In fact, some of the blame for the stock market crash has been laid on the markets for derivatives (e.g., stock index futures). The alleged direction of causality (even implied in the Brady Commission Report) goes from stock index futures to the stock index. This, we argue, is in contrast with the evidence. The evidence seems to go the other way around: the stock market index affecting the stock index futures. For stocks and stock index futures that are traded in two different bourses, we show the direction of causality goes in one direction only. In particular, for Nikkei index and Nikkei index futures the causation goes from the stock market to the derivative in an unidirectional fashion.

Our study here can be seem as a complement to the Commodity Futures Trading Commission (CFTC) Report on the stock market crash of 1987. The Report finds (Section II) when the reported futures discount was extreme (morning of October 19, 20 of 1987), a significant portion of these discounts were illusory since a substantial number of stocks included in the S&P 500 index were not actively trading. These finding casts doubt upon the supposition that futures prices were leading the stock market as a reasonable representation of what occurred during the morning of October 19, 1987. CFTC Report (along with others) missed one important point about the crash: the substantial decline in stock prices in other markets took place *before* the (subsequent) decline

in the US stock (and other derivatives) markets (Roll (1989)). The sharp decline really took place in the Nikkei index first (although there was a decline in the Dow Jones Industrial Average on the preceding Friday October 16, 1987). Thus, it is natural to look at the relation between the Nikkei index and Nikkei index futures markets.

The rest of the paper is arranged as follows: in the next section, we make a precise statement of the problem studied. In section 3, we provide the analysis. The final section contains concluding comments.

2. The Problem

There is a strong connection between a stock market and the market for the corresponding stock index futures. The stock index futures simply fills the void of missing markets for all contingencies. Therefore, both the stock market and the stock index futures are both driven by the same underlying macroeconomic processes. However, even if the link between these two types of markets are not disputed, the direction of influence is by no means obvious.

The context here is comparable to the situation of a possible relation between money supply and real GNP. That there is a relation is not disputed by any macroeconomist. But the direction of relationship sets apart a Keynesian from a monetarist (Sims, 1972). Thus, we use the Granger causality test to (statistically) ascertain the nature of causality between a stock market and the corresponding stock index futures. It becomes even more interesting because the Nikkei index futures is traded in the Singapore International Monetary Exchange (and not anywhere in Japan). Thus a study of the link between the Nikkei index and the

Nikkei index futures uncovers the international dimension of the stock markets.

3. Tested Hypotheses

Granger causality test is a four step process (Box and Jenkins, 1976, Chapter 4): (1) Each series is prewhitened by building ARIMA (p, d, q) series. The components p and q are identified by inspecting plots of the autocorrelation (and partial autocorrelation) functions. (2) The cross correlations are examined to see possible causations (for example, X causes Y unidirectionally if $c(k) = 0$ for all $k < 0$ and $c(k) > 0$ for some $k > 0$ where $c(k)$ is the cross correlation function at lag k). (3) If unidirectional causality is suspected, a transfer function is constructed (Box and Jenkins, 1976, p. 337). (4) The model in (1) and (3) are put together for the original data.

There were two separate Nikkei index futures contracts traded during the crash: the Nikkei December 1987 (NKDEC) and Nikkei March 1988 (NKMAR). We considered data from September12, 1987 to the expiration dates of the futures: NKDEC expired on December 12, 1987 and NKMAR expired on March 16, 1988. The data for the Nikkei spot (NKSP) and Dow Jones Industrial Average (DJIA) were used for the same time period. There were some days in there for which NKDEC and/or NKMAR traded but Tokyo and/or New York did not, we deleted all those days from our data sets.

We first ran a set of diagnostics tests for spurious autocorrelations (using simple Durbin Watson statistics): the tests results produced non-spurious correlations.

Granger Causality tests were performed to test the following hypotheses: (1) changes in NKSP is caused by NKDEC; (2) changes in

NKSP is caused by NKMAR; (3) changes in DJIA is caused by NKDEC; and (4) changes in DJIA is caused by NKMAR. All four hypotheses were rejected and unidirectional causality were established from (1) NKSP to NKDEC; (2) NKSP to NKMAR; (3) DJIA to NKDEC; and DJIA to NKMAR as shown in the table below:

Table 1

series	*model used*	*prewhitening filter used*	*unidirectional causality*
NKSP/NKDEC	(1,3,0)	1+.348B	yes (at 5%)
NKSP/NKMAR	(1,2,0)	1+.277B	yes (at 5%)
DJIA/NKDEC	(1,[1,15],0)	1+.385B	yes (at 5%)
DJIA/NKMAR	(1,{1.14],0)	1+.385B	yes (at 5%)

The details of the tests are spelled out in the appendix of the paper (the ETS package of the SAS program was used)

4. Conclusion

We can criticize the above analysis by pointing out that the data came from *daily* trading prices. Would it not be better to look at intraday trading prices and analyze the hour by hour (or perhaps minute by minute) data? First problem with that is there is no publicly available data SIMEX. Second, more importantly, what does the data tell us even if we did have it available. We know that trading were actually delayed (due to process bottlenecks) by hours during October 19 and 20, 1987. So, the signals from such data will have a large noise component. Hence the use of intra-day trading data could be a mixed blessing.

Important shortcoming of the paper comes from more recent events. During the first three months of 1990, Nikkei lost a third of it's value. At the same time, the Dow Jones Industrial Average went from strength to strength. What do these events do to compare with the causality we studied for 1987 events. At present, we are engaged in looking at such datasets. The analysis will definitely add to our understanding of the cross country markets for derivatives.

References

Box, G and Jenkins, G. **Time Series Analysis.** (Holden Day, CA: 1976).

Roll, R. The International Crash of October 1987. in **Black Monday and Future of the Financial Markets** (Dow Jones Irwin, Homewood, IL. 1989).

Sims, C. "Money Income Causality", *American Economic Review*, 1972.

APPENDIX

FIGURE 1

CORRELATION OF NKDEC AND NKSP
NKSP HAS BEEN DIFFERENCED
PERIOD OF DIFFERENCING = 1
BOTH SERIES HAVE BEEN PREWHITENED
VARIANCE OF TRANSFORMED SERIES = 4026087 AND 582426
NUMBER OF OBSERVATIONS = 44
CROSSCORRELATIONS

LAG	COVARIANCE	CORRELATION	-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
-5	74626	0.04873	. * .
-4	241494	0.15770	. *** .
-3	44971	0.02937	. * .
-2	-102445	-0.06690	. * .
-1	-1764111	-0.11520	. ** .
0	778752	0.50855	. **********
1	797890	0.52105	. **********
2	807255	0.52717	. **********
3	-156398	-0.10213	. ** .
4	-170634	-0.11143	. ** .
5	-1419	-0.00093	. .

"." MARKS TWO STANDARD ERRORS

NOTE: CROSS CORRELATIONS FOR LAGS 0, 1, AND 2 EXCEEDS 2 STANDARD DEVIATIONS IMPLYING UNIDIRECTIONAL CAUSALITY BETWEEN NKSEP AND NKDEC

CROSS CORRELATION CHECK BETWEEN SERIES

LAG	CHI SQ.	DF	PROB	CROSSCORRELATIONS					
5	36.56	6	0.000	0.509	0.521	0.527	-0.102	-0.111	-0.001
11	37.96	12	0.000	0.064	0.020	-0.104	-0.122	-0.034	0.021
17	39.07	18	0.003	-0.005	-0.008	0.025	0.097	0.116	0.040
23	40.18	24	0.020	-0.051	-0.066	-0.086	-0.065	-.075	-0.033

BOTH VARIABLES HAVE BEEN PREWHITENED BY THE FOLLOWING FILTER (AUTOREGRESSIVE FACTORS)
FACTOR1 1+ 0.347937B

NOTE: THE CROSS CORRELATION CHECK OF ZERO CROSS CORRELATION AT 5% IS REJECTED

FIGURE 2

CORRELATION OF NKMAR AND NKSP
NKSP HAS BEEN DIFFERENCED
PERIOD OF DIFFERENCING = 1
BOTH SERIES HAVE BEEN PREWHITENED
VARIANCE OF TRANSFORMED SERIES = 1310947 AND 304227
NUMBER OF OBSERVATIONS = 104
CROSSCORRELATIONS

LAG	COVARIANCE	CORRELATION	-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
-5	54156	0.08576	. ** .
-4	27699	0.04386	. * .
-3	4952	0.00784	. .
-2	-13720	-0.02173	. .
-1	-26280	-0.04161	. * .
0	414474	0.65630	.**********
1	412209	0.65272	.**********
2	-30675	-0.04857	. * .
3	12822	0.02030	. * .
4	-46085	-0.07297	. .
5	-1		

"." MARKS TWO STANDARD ERRORS

NOTE: THE CROSS CORRELATION FOR LAGS 0 AND 1 EXCEEDS TWO STANDARD DEVIATIONS IMPLYING UNIDIRECTIONAL CAUSALITY BETWEEN NKSP AND NKMAR

CROSS CORRELATION CHECK BETWEEN SERIES

LAG	CHI SQ.	DF	PROB	CROSSCORRELATIONS					
5	90.00	6	0.000	0.656	0.653	-0.049	0.020	-0.073	-0.023
11	93.05	12	0.000	0.082	-0.089	-0.118	-0.024	-0.001	0.013
17	94.80	18	0.000	0.008	-0.003	0.044	0.085	0.082	0.032
23	95.53	24	0.000	-0.034	-0.003	-0.028	-0.066	-0.020	-0.019

BOTH VARIABLES HAVE BEEN PREWHITENED BY THE FOLLOWING FILTER (AUTOREGRESSIVE FACTORS)
FACTOR1 1+ 0.22711B
NOTE: ZERO CROSS CORRELATION IS AGAIN REJECTED AT 5% LEVEL.

FIGURE 3

CORRELATION OF NKDEC AND DJIA
NKSP HAS BEEN DIFFERENCED
PERIOD OF DIFFERENCING = 1, 15
BOTH SERIES HAVE BEEN PREWHITENED
VARIANCE OF TRANSFORMED SERIES = 2491213 AND 11936
NUMBER OF OBSERVATIONS = 37
CROSSCORRELATIONS

LAG	COVARIANCE	CORRELATION	-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7
-5	-9089	-0.05271	
-4	4099	0.02377	
-3	-8436	-0.04892	
-2	14812	0.08590	
-1	5330	0.03091	
0	-17764	-0.10302	
1	16889	0.09795	
2	-48610	-0.28190	
3	-30949	-0.17948	
4	139072	0.80651	
5	50369	0.29210	

"." MARKS TWO STANDARD ERRORS

NOTE: CROSS CORRELATIONS FOR LAGS 4 AND 5 EXCEED TWO STANDARD DEVIATIONS IMPLYING UNIDIRECTIONAL CAUSALITY BETWEEN DJIA AND NKDEC.

CROSS CORRELATION CHECK BETWEEN SERIES

LAG	CHI SQ.	DF	PROB	CROSSCORRELATIONS					
5	32.10	6	0.000	-0.103	0.098	-0.282	-0.179	0.807	0.292
11	41.24	12	0.000	-0.417	-0.011	-0.035	-0.160	0.051	0.208
17	41.24	18	0.001	-0.001	-0.043	-0.008	-0.052	-0.006	0.008
23	41.98	24	0.013	0.037	0.022	-0.018	-0.034	0.019	0.108

BOTH VARIABLES HAVE BEEN PREWHITENED BY THE FOLLOWING FILTER (AUTOREGRESSIVE FACTORS)
FACTOR1 1+ 0.38542 B
NOTE: ZERO CROSS CORRELATION IS AGAIN REJECTED AT 5% LEVEL.

FIGURE 4

CORRELATION OF NKMAR AND DJIA
NKSP HAS BEEN DIFFERENCED
PERIOD OF DIFFERENCING = 1, 14
BOTH SERIES HAVE BEEN PREWHITENED
VARIANCE OF TRANSFORMED SERIES = 915353 AND 5943
NUMBER OF OBSERVATIONS = 102
CROSSCORRELATIONS

LAG	COVARIANCE	CORRELATION	-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
-5	2170	0.02942	
-4	-8979	-0.12174	
-3	4479	0.06073	
-2	6439	0.08730	
-1	-7529	-0.10209	
0	8694	0.11787	
1	-9397	-0.12740	
2	-6392	-0.08667	
3	47703	0.64677	
4	16969	0.23006	
5	-17565	-0.23814	

"." MARKS TWO STANDARD ERRORS

NOTE: FOR LAGS 3, 4 AND 5 THE CROSS CORRELATIONS EXCEED TWO STANDARD DEVIATIONS IMPLYING UNIDIRECTIONAL CAUSALITY BETWEEN DJIA AND NKMAR.

CROSS CORRELATION CHECK BETWEEN SERIES

LAG	CHI SQ.	DF	PROB	CROSSCORRELATIONS					
5	57.69	6	0.000	0.118	-0.127	-0.087	0.647	0.230	-0.238
11	65.46	12	0.000	0.006	-0.096	-0.122	-0.128	0.184	0.043
17	66.69	18	0.000	-0.041	0.007	-0.072	-0.061	0.018	0.032
23	68.22	24	0.000	0.009	0.045	0.045	0.060	0.062	0.059

BOTH VARIABLES HAVE BEEN PREWHITENED BY THE FOLLOWING FILTER (AUTOREGRESSIVE FACTORS)
FACTOR1 1+ 0.385421B
NOTE: ZERO CROSS CORRELATION IS AGAIN REJECTED AT 5% LEVEL.